Presidential Address

Delivered at a meeting of the Society held at the Institution of Electrical Engineers, London, W.C.2, on Friday, January 23, 1959.

By R. L. SMITH-ROSE, C.B.E., D.Sc., Ph.D., F.C.G.I., M.I.E.E.

In the first section of the Address an outline is given of the early days of the Society. Reference is then made to international radio organizations—including the I.A.R.U.—and to the forthcoming Administrative Radio Conference due to take place in Geneva later this year. In the second section the function of the Radio Research Board with particular reference to the work being done at the Radio Research Station, Slough, is discussed. The back-scatter method used for the preparation of frequency predictions is then considered in some detail.

MY first duty tonight is to thank you, Sir, the Council and the members of the Society, for the honour you have all done me in electing me as President for the ensuing year. As you know, Sir, when we first discussed this matter some time ago, I said that I thought the Society ought to have a practising amateur at its head. But I had to admit that one can be engaged professionally in the science or practice of radio and still remain an amateur—a word which is derived from the Latin " amo " to love, and indicates a person who cultivates any study, art or science from sheer attachment or devotion to it. I am told that among my claims to distinction in this office is that I am one of the few surviving members (but by no means the oldest, as I learnt at a recent dinner) of the London Wireless Club which was founded in 1913 by Mr. Rene Klein: and which, before its first formal meeting in January 1914, had changed its name to the Wireless Society of London.

The Early Days

I have few personal records of the early history of the Society, but those who are interested may be reminded that the proceedings of the Society were for some years published in *The Wireless World and Radio Review* as a well-known British technical publication was then called. From this source I find that it was at the Ordinary Meeting of the Society held on September 27, 1922 that it was decided to change the name to the present one, and this persists today in being known by the initial letters R.S.G.B. Incidentally, at the following meeting on October 25, 1922 my colleague, Dr. R. H. Barfield, and I were privileged to read our first paper before the Society on "The Effect of Underground Metalwork on Radio Direction Finders." The meeting was of especial interest to us as it was conducted under the chairmanship of the Society's President, Admiral of the Fleet, Sir Henry B. Jackson, who was also chairman of the Radio Research Board which has been the advisory body on radio matters to the Department of Scientific and Industrial Research since its formation in 1919.

Coming-of-Age Celebrated

On July 5, 1934 the Incorporated Radio Society of Great Britain celebrated the 21st anniversary of its formation by the publication of a special commemorative issue [1] of its BULLETIN.* The issue contained a congratulatory message from the Patron of the Society, H.R.H. the Prince of Wales, together with contributions from many of the Past Presidents and other prominent members in the radio field. The same issue of the T and R BULLETIN—as it was then called—also contains an historical review of the Society's twenty-one years of progress to that date. I commend this issue to the attention of the younger members of our Society who may like to understand something of the excellent work carried out by the pioneer members who provided the foundation upon which the Society has built its reputation in both the national and international field. Since its foundation in 1925 the BULLETIN has continued to provide a running commentary of the activities of its members to the present time. For those interested in more details of the early work and development of the Society, I refer them to an excellent series of articles [2] by Mr. C. H. L. Edwards. These articles review the progress made and the widespread activities engaged in by members during the period 1925 to 1950; and the story they tell surely demonstrates the full justification of the existence of Amateur Radio as a most interesting and satisfying hobby. You, Sir, in your Presidential address a year ago gave an excellent presentation of this theme. If I may have your permission, I should like to re-echo your thoughts by quoting from the closing words of this address. " Our grand hobby has no equal; it is worth every effort to ensure not only its continuance, but its future growth. Let us be sure that individually and collectively we play our part and do not rest on the achievements of a receding past to see us through."

Towards the Golden Jubilee

I do not propose to spend any more time in this address in reviewing historical developments, except to draw to the attention of the younger members, that it must fall upon them to prepare for the Golden Jubilee celebrations which will undoubtedly be called for in 1963, when the Society will have become 50 years old. The history that will have to be prepared for this occasion will contain an embarrassing list of historic firsts; I wonder who will be the first to establish a two-way contact between the earth and another planet; the exchange of messages with an unmanned artificial earth satellite having already been accomplished by our friends on the other side of the Atlantic Ocean.

International Radio

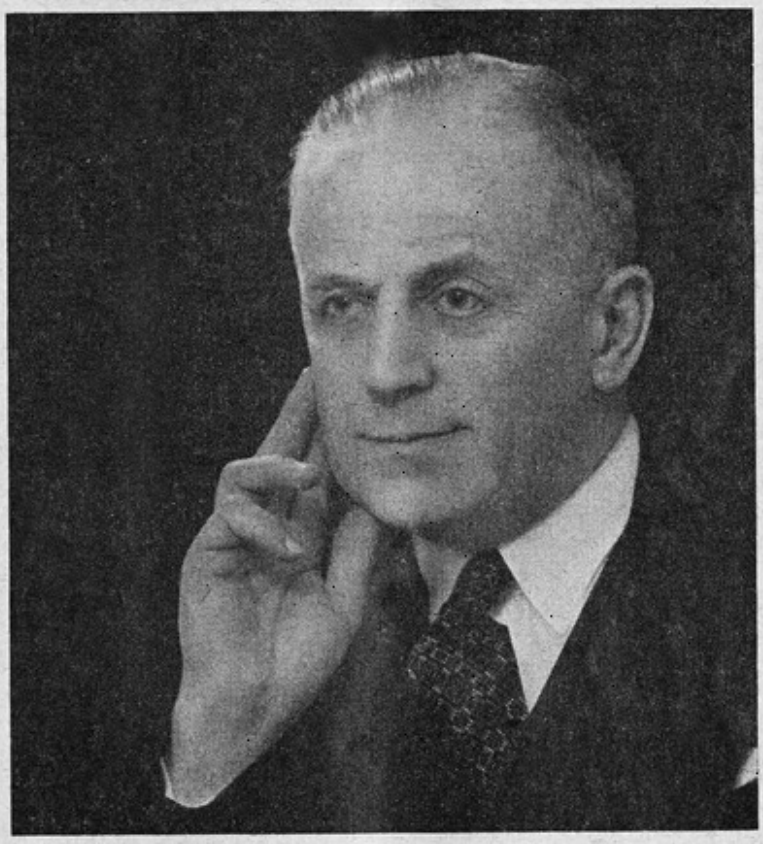
Before turning to the more technical part of this address, I would like to say a few words on a subject which is very close to my heart and towards which all who are engaged in radio research and experimental work are directed sooner or later. I refer to the question of international associations in radio affairs. Few amateurs can pursue this hobby for long before coming into contact by speech or Morse signals with their fellow enthusiasts in other countries. The exchange of messages is followed by the exchange of QSL cards and this inevitably leads to an increased knowledge of geography and, for the real enthusiast, of other languages. In due time contemporary amateurs visit and meet one another, not only on their own soil but also in other countries; and this leads, apart from an actual exchange of technical knowledge and experience, to a wider and better understanding of the conditions and problems encountered by our fellow beings in

* *See references at end.*

other countries. Some of you become representatives of your country and society at international discussions and conferences, where you have the responsibility of upholding the interest of your own nation and also of understanding the problems of those in other lands. In this way the hobby of Amateur Radio, while being entirely non-political in its aims and associations, can continue to make an important contribution to the peace of the world, and the happiness of the individuals in it.

The year 1959 will indeed be an historic one as far as international radio matters are concerned. Not only will C.C.I.R. be holding its 9th Plenary Assembly in Los Angeles in April; but an Ordinary Administrative Radio Conference under I.T.U. auspices will take place in Geneva later in the year. At this conference the existing Atlantic City Regulations and Frequency Allocations will be revised and brought up to date.

It may be of interest here to describe briefly the organization of international affairs on the scientific and technical sides of radio communications. In another publication [3] I have described the general constitution and activities of the International Scientific Radio Union (U.R.S.I.), which operates under UNESCO, and the International Radio Consultative Committee (C.C.I.R.) which is a technical advisory body of the International Telecommunication Union (I.T.U.). Amateurs do and can continue to make some contribution to the work of both these bodies. For example, one group of enthusiastic members of our Society, led by Messrs. G. M. C. Stone and C. E. Newton, has been conducting some interesting and useful work in connection with the International Geophysical Year with the encouragement of a committee of the Royal Society associated with U.R.S.I. On the more practical side, the R.S.G.B. is represented by Mr J. Clarricoats, our General Secretary, on the appropriate Post Office committee through which the British representation to C.C.I.R. is obtained. Similar representation exists on the Frequency Advisory Committe set up last year by H.M. Postmaster General.



Dr. R. L. Smith-Rose, C.B.E.

The I.A.R.U.

But an important function of our own Society is to participate in an effective organization of radio amateurs on an international basis. This is done through the International Amateur Radio Union (I.A.R.U.).

The I.A.R.U., which is a union of national radio societies, is permitted to appoint observers to attend meetings of the International Telecommunication Union. These observers work in close collaboration with government delegations and are thus able to make known the wishes and aspirations of amateurs in the all-important matter of frequency allocations. Mr. A. E. Watts attended the I.T.U. conferences in Madrid (1932) and Cairo (1938) as an I.A.R.U. observer, while Mr. Clarricoats and Mr. S. K. Lewer (then President of the Society) attended the conference held in Atlantic City in 1947 in similar capacities. They played their part in securing the various bands of frequencies which have been available to amateurs for the past decade.

Prior to each I.T.U. conference the R.S.G.B., in common with other national societies, discusses its problems with representatives of the G.P.O. and other government departments. That procedure is being followed at the present time in preparation for the I.T.U. conference in Geneva later this year.

An article by Mr. Lewer [4] describing the activities of the I.A.R.U. during the first twenty-five years of its existence was published in the BULLETIN for April 1951. The Union is an organization without funds of its own, and much of its progress to date has been due to the generosity of the American Radio Relay League, through which, in effect, their journal *QST* became the official organ of the I.A.R.U. [5]. Shortly after the Atlantic City conference the R.S.G.B. took the initiative to organize and promote the interests of I.A.R.U. Societies in Region I (Europe, Africa and parts of Asia). This Region I Division, as it is called, was established at a conference held in Paris during 1950 to mark the 25th anniversary of the foundation of the I.A.R.U. Subsequent meetings have been held at Lausanne in 1953, at Stresa (Italy) in 1956 and at Bad Godesberg (Germany) in 1958. On the last occasion it was decided to hold the next conference in this country during 1960. It is gratifying to note that our Society is held in such esteem by the representatives of other countries, that at the Bad Godesberg conference our Mr. Clarricoats was elected secretary of the Region I Division and appointed to represent the I.A.R.U. at the forthcoming I.T.U. conference. It is hoped that the R.S.G.B. will be separately represented by my predecessor Mr. L.E. Newnham.

The D.S.I.R. Radio Research Station, Slough

I propose to devote the remainder of this address to giving you a brief account of some aspects of the work of the Radio Research Station in studying the characteristics of the ionosphere and the manner in which high frequency radio waves are propagated over world-wide distances. In the first place, let me explain that the Radio Research Station [6] is one of a number of specialized research laboratories organized under the Department of Scientific and Industrial Research; and it is actively engaged on an expanding programme of research which was formerly conducted in the Radio Division of the National Physical Laboratory at Teddington. A major part of this programme is designed to assist those responsible for developing and operating radio services in the fields of communications, broadcasting including television, and aids to aerial and marine navigation.

The efficient and economical use of the radio-frequency spectrum depends to a large extent on a detailed understanding of the modes of propagation of waves of all

frequencies and for all conditions of transmission over the ground and through the upper and lower atmosphere. Research is also undertaken on atmospheric noise with the view of minimizing its effect as a source of interference. To assist in the conduct of this work on a world-wide basis, observatories or substations are staffed and maintained at Inverness, Singapore and at Port Stanley in the Falkland Islands. Direct co-operative assistance is also provided for similar observatories installed at University College, Ibadan, Nigeria, and at Port Lockroy, Grahamland, Antarctica.

Special assistance has also been given to the Royal Society's expedition to Halley Bay in the Antarctic, where a special programme of ionospheric measurements has been carried out during the International Geophysical Year. With the launching of artificial earth satellites by the U.S.A. and U.S.S.R. authorities, observations have been made at Slough and Singapore and these have led to the formulation of a new programme of space research for the future.

Apart from this extensive study of radio wave propagation, a study is made of certain characteristics of semi-conductors, magnetic materials and transistors in order to gain a better understanding of their suitability at increasingly higher radio frequencies.

The Radio Research Station is also responsible for developing secondary standards and the associated techniques for measuring power, field strength and other quantities at very high radio frequencies. The results of this programme of research are described in papers published in the proceedings of scientific societies, technical institutions and in various periodicals. In addition a continuous series of abstracts and references to the world's radio literature is published monthly in *Electronic and Radio Engineer* (*London*) and *The Proceedings of the Institute of Radio Engineers* (New York).

Propagation of High Frequency Waves

As already mentioned, the Radio Research Station is responsible for the maintenance of seven observatories—two in the United Kingdom and five on British territory overseas—which make a continuous study of the characteristics of the ionosphere by vertical sounding technique. In this procedure a pulse of radio waves is emitted vertically upwards and a photographic record is made of the time taken for the echo pulse to return to the ground after reflection at one or other layers of the ionosphere. By varying the frequency of the radio waves, a direct measurement of ionospheric conditions over the observing station is carried out at frequent intervals day and night. The results obtained at our own observatories are exchanged with those of other national administrations, and in this way a continuous picture is obtainable at over 200 points in the ionosphere throughout the world. From a continuous study of these observed results over one or more sunspot cycles, each of about eleven years' duration, forecasts are prepared of the expected state of the ionosphere all over the world, six months in advance. By interpolation between the points where measurements have been made, corresponding forecasts of radio transmission conditions are made and supplied to the operators of all types of radio services for organizing their future schedules. This interpolation, however, must assume a knowledge of ionospheric conditions over large areas of the world where no observatories exist, including the oceans; and experience has shown that these conditions are subject to irregularities in both space and time which are difficult to take into account and thus place a limitation on the accuracy of forecast of the transmission or propagation conditions.

Two lines of research are being pursued at the Radio Research Station with a view to removing this deficiency, for the direct measurement of ionospheric conditions at points in the ionosphere remote from the observing station. In the most recently developed technique, a special transmitter was set up in Malta to sweep over the frequency band of 5·5 to 25 Mc/s in steps of 20 kc/s, each step lasting 0·4 seconds. The receiver at Slough sweeps over the same band, the two sets of equipment being kept in synchronism by very stable crystal clocks. Observations of the signals received under these conditions provide a useful means of studying the ionospheric conditions near the midpoint of the path some 2,000 km in length. Plans are in hand for extending the work to greater distances in the future. The alternative method of observing the mode of propagation of radio waves over distances of several thousand miles has been developed to a great extent in this country and in the U.S.A. The work for which the Radio Research Station is responsible is described in more detail in the next section.

Application of Back-Scatter Technique

This method makes use of what is termed the "back-scatter" phenomenon, whereby some of the energy of radio waves sent from a transmitter is scattered back from a distant point and the resulting signals may be received near the transmitter and even on the same aerial. The fact that radio waves could be scattered from clouds of ionization in the E region was reported by Appleton and his collaborators [7] during the second International Polar Year and has since been investigated by several workers. Later, T. L. Eckersley [8] made a comprehensive analysis of scattering effects in radio transmission and identified two main categories of echoes received by wave scattering, when operating at frequencies above the normal incidence critical frequency of the ionosphere.

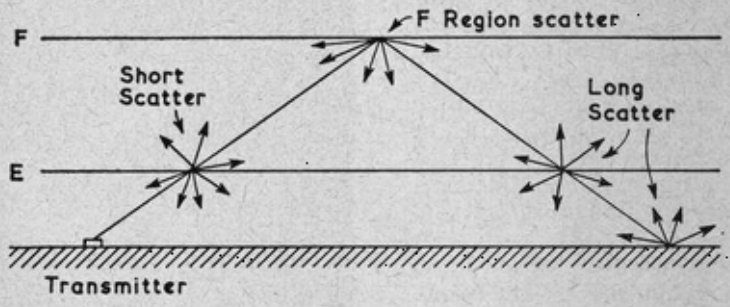


Fig. 1. Sources of scatter.

The main features of the phenomenon of wave scattering are illustrated in Fig. 1. The three types of scattering which affect high-frequency propagation are (i) short scatter from ionic clouds in the *E* region illuminated by upgoing radiation from a transmitter, (ii) scattering from the *F* region when it is turbulent, such as during a storm in the ionosphere, and (iii) long scatter from the ground or from *E* region clouds illuminated by down coming radiation from the *F* region. In each case, as indicated in the figure, some of the energy scattered by these processes is returned along the incident path and can be detected by a receiver near the transmitter and within the skip zone.

If pulse-modulated signals are radiated by a transmitter, and the received echoes are displayed on a linear time base on a cathode-ray tube, the pattern seen will be as illustrated in Fig. 2. For frequencies below the critical value, a succession of normal echoes reflected from *F* region by one, two, and three hops are received, and it will be noticed that the echo due to the second-order reflection (*2F*) is accompanied by some scattered echoes of smaller magnitude. There is also noticeable a small amount of scatter from the *E* region. As the critical frequency is approached, the delay time of the normal *F*-region echoes, expressed in terms of the equivalent path,* increases; when the frequency is above the critical frequencies for all modes, the echoes that remain are due to

* *In view of the lack of uniformity among different observers in expressing their results, it may be pointed out here that a time delay of 10 m-sec. corresponds to an equivalent path from source to point of reflection or scattering of 1,500 km.*

the short and long scatter (see Fig. 2). It will be observed that the long scatter can arise either by reflection from a distant ionic cloud in the *E* region, or by scattering from the ground at a somewhat greater distance.

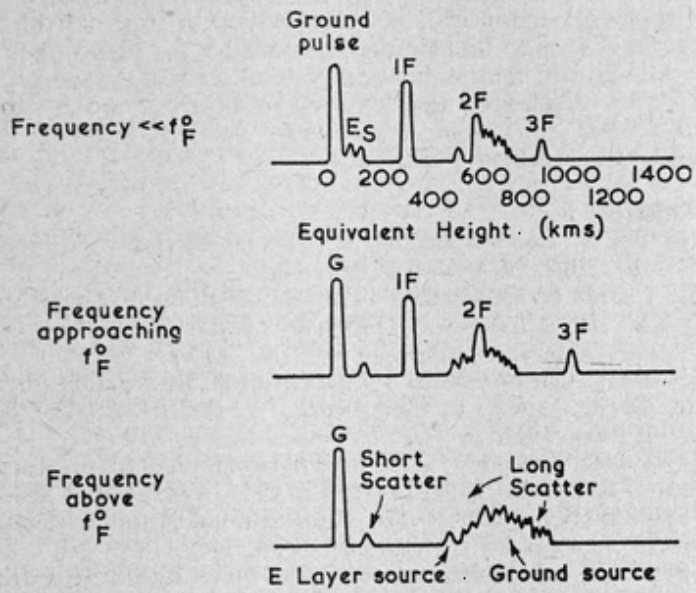


Fig. 2. Echo patterns seen on a time-base display.

This double source of the long-distance scattered echoes was clearly recognized by Eckersley, who concluded that scattering from the *E* region was more common than from the ground. Later investigations, however, conducted in Europe and America have demonstrated that this is not normally the case. For example, experiments made at the D.S.I.R. Radio Research Station, [9] Slough, England, have shown that the ground-scattered type of echo predominates. The results of an experiment made in June 1949, demonstrating this are displayed in Fig. 3. By varying the transmitted frequency and measuring the time delay of the leading edge of the scattered echo, results were obtained which are seen to lie on a straight line which is tangential to the *2F* reflection curve at the point representing the minimum delay for the critical frequency. If the reflection had been from the *E* region on this occasion, the delay would have been less as indicated by the lower straight line which does not meet the *2F* reflection curve.

A number of records taken at Slough [10] in a study of the variation of path length with frequency show close agreement between the calculated and observed path lengths on the basis of scattering at the ground. Path lengths were observed both longer and shorter than the theoretical ground-scatter value with the mean values lying between ± 2 per cent. The corresponding path length for *E*-region scatter would lie between extremes of −11 and −18 per cent. Random differences between the calculated and observed path lengths were to be expected, since the ionosphere is rarely, if ever, uniform over an area of 500 km radius, which was used in these experiments.

The general conclusion from these experiments was, therefore, that the sources of the scattered echoes were mainly, if not entirely on the ground and not in the *E* region of the ionosphere. As a result of calculations of the intensity of the echoes for a thin reflecting layer in the ionosphere, it is concluded that, to a first approximation, the irregularities present on land and sea are fully sufficient to account for the echoes observed.

So far, consideration has been confined to ground or *E*-region scatter reflected by the *F* layer. Echoes are frequently seen, however, and particularly in summer, which are due to energy scattered by the ground and reflected on the outward and return journey by the *Es* (or sporadic *E*) layer. Such echoes can be identified on the photographic records by the emergence of the scattered echo from the *2Es* vertical-incidence echo, and increasing in range in accordance with the target relationship with the appropriate *Es* height frequency curve.

In much of the work so far discussed, the comparison between experiment and theory has been based on the assumption that the earth and reflecting layers are plane, and this is a reasonable approximation to make for ground ranges up to about 900 km. To provide for the extension of the work to greater distances, Shearman [10] has examined the corresponding conditions for a curved earth, and also for a thick, reflecting layer with a parabolic distribution of ionization against height. Under these conditions it is necessary to consider the effect of ray focusing on the echo intensity; and this focusing effect has been shown to result in a threefold increase of field strength at the skip distance over that obtained from a thin reflecting layer.

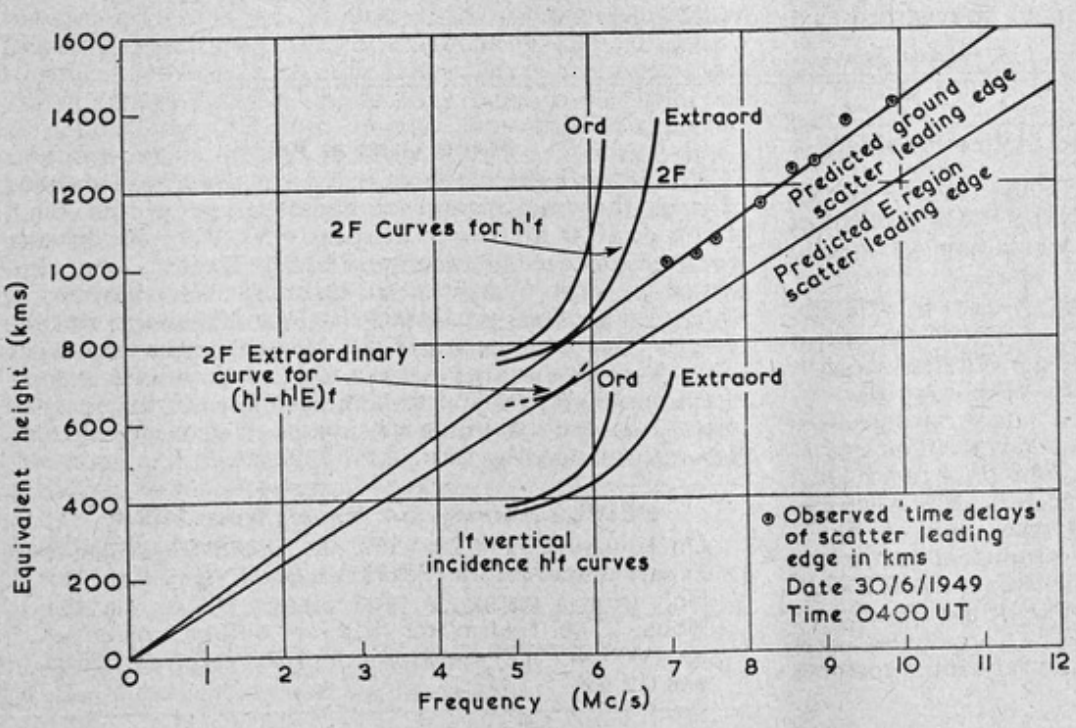


Fig. 3. Time delays of leading edge of long-scatter groups.

Shearman (10) has also presented the results of further investigations and an analysis of a year's observations of long-range back-scatter at Slough. A pulse transmitter of 150 kW peak power coupled to alternative directional aerials was used, and transmissions were made at noon each day on a number of frequencies between 10 and 27 Mc/s. With the increased transmitter power available, single-hop echoes could be received from ranges up to 3,000 km (1,900 miles), and multihop echoes from ranges up to 11,000 km. (nearly 7,000 miles). There was thus a considerable difference in the geographical position of the reflection point for different directions of propagation, and since conditions in the ionosphere vary

greatly with latitude and longitude, there was a marked variation of skip distance with bearing.

The idea that the use of back-scatter techniques could be applied to sounding the ionosphere under oblique incidence conditions and for predicting the maximum usable frequencies for radio transmission appears to have been due to Newbern Smith of the National Bureau of Standards, U.S.A. It is clear that the scope of such an investigation of ionospheric conditions can be considerably extended by using a rotatable directive aerial system. The conception of the use of a radar-type plan-position indicator (PPI) for skip-distance indication is also attributed to Newbern Smith, and this method has now been developed by a number of investigators.

At the Radio Research Station a rotating aerial and PPI system has been in use on a frequency of 17 Mc/s before and during the I.G.Y. in an investigation of the diurnal and seasonal changes in back-scatter conditions in the south-east of England. By superimposing an outline map on the face of the cathode-ray tube, the zones of the earth from which echoes are being returned, and to which radio communication is therefore possible, are at once obvious. Photographs of the screen of the tube can be taken and these show the regions of the earth from which the scattered radiation is returned as dark zones. When the frequency of transmission was 17 Mc/s (which is above the maximum frequency for which oblique rays could be reflected by the ionosphere at night) it may be low enough for reflection to take place from those areas of the ionosphere illuminated by the sun.

By using cinematograph film technique, photographs of this type can be taken for each rotation of the aerial and time base at one revolution per minute. After processing, the exposed film can be projected at the normal speed of 16 frames per second, so that the changes occurring during 24 hours may be seen in 1½ minutes. In this way a very interesting and vivid display can be produced of the changes in ionospheric conditions around the observing station. The study of such films, taken at regular intervals, provides a quick and efficient means of investigating the diurnal and seasonal changes in the ionosphere and should do much to assist in the application of the technique to forecasting communication conditions on a short-term basis.

It is clear from the experience already obtained that the back-scatter technique is not a substitute for the present practice of making predictions based upon the results obtained from the world-wide network of vertical incidence ionospheric observatories. Rather it is to be regarded as a supplementary device for assisting in the assessment of the effects of short-period fluctuations of ionospheric conditions and possibly as a better means of indicating the onset of storms or turbulence than is at present available. With a realization of its limitations, however, there is no doubt that this use of wave scattering phenomena has provided the radio scientist with a powerful new tool which in time will be of great assistance to the engineer responsible for planning and operating radio communication systems around the world.

(A film displaying the features to be observed by this back-scatter technique was shown at the end of the Presidential Address.—EDITOR.)

References

[1] The T. and R. BULLETIN: Special Birthday Number. R.S.G.B., June 1934, Vol. 9, No. 12.

[2] C. H. L. Edwards, "The R.S.G.B. in Retrospect," R.S.G.B. BULLETIN, July 1954 to March 1955, Vol. 30, Nos. 1, 2, 3, 5, 7, 8 and 9.

[3] R. L. Smith-Rose, "International Radio Organizations: Some Aspects of their Work," *J. Brit.I.R.E.*, Vol. 18, No. 11, Nov. 1958.

[4] S. K. Lewer, "The International Amateur Radio Union," R.S.G.B. BULLETIN, April 1951, Vol. 26, pp. 380-1.

[5] P. B. Schroeder, "The International Amateur Radio Union," *Journal I.T.U.*, January 1958, No. 1, pp. 3-8.

[6] R. L. Smith-Rose; (a) "The New Radio Research Station," *Nature*, 1957, Vol. 180, pp. 163-166; (*b*) "The Radio Research Station, Slough," *Nature*, 1958, Vol. 181, pp. 1642-1643.

[7] E. V. Appleton, R. Naismith and L. J. Ingram, "British Radio Observations during the Second International Polar Year 1932-33," *Phil. Trans. Roy. Soc. A*, 1937, Vol. 236, pp. 191-259.

[8] T. L. Eckersley, "Analysis of the Effect of Scattering in Radio Transmission," *Journal Inst. Elec. Engrs.*, 1940, Vol. 86, pp. 548-562.

[9] *Radio Research 1949*, Department of Scientific and Industrial Research, H.M.S.O., London, 1951.

[10] E. D. R. Shearman; (a) "The Technique of Ionospheric Investigation using Ground Back-Scatter," *Proc. Inst. Elec. Engrs.*, 1956, Vol. 103, pp. 210-223; (b) "A Study of Ionospheric Propagation by Means of Ground Back-Scatter," *Proc. Inst. Elec. Engrs.*, 1956, Vol. 103, pp. 203-209.

[11] E. D. R. Shearman and L. T. J. Martin; "Back-Scatter Ionospheric Sounder," *Wireless Engineer*, 1956, Vol. 33, pp. 190-201.

Mr. W. H. Allen (G2UJ) elected a Vice-President

AT its meeting on January 22, 1959, the Council elected Mr. W. H. Allen, M.B.E. (G2UJ) a Vice-President of the Society in recognition of his outstanding services to Amateur Radio over a period of many years.

Mr. Allen joined the R.S.G.B. as B.R.S. 1441 in 1934 and was first licensed as G2UJ in January 1935. He was a member of the pre-war R.A.F. Civilian Wireless Reserve and became an "Early Bird" with 60 Group R.A.F. (W.I.S.) in September 1939. He was later transferred to Signals Intelligence. After ten months attachment on special duties to the British Legation in Stockholm prior to VE Day, for which work he was awarded the M.B.E., Mr. Allen left the R.A.F. in November 1945 with the rank of Flight Lieutenant. He has for long played a prominent part in the affairs of the Society and was for some years the R.S.G.B. V.H.F. Manager. Mr. Allen is a member of the Handbook, Publications; Technical and V.H.F. Committees. He is President of the West Kent Radio Society and a member of the London U.H.F. Group.

Moon Used as Relay

TESTS using the moon as a passive relay have resulted in the transmission of radioteletype in the u.h.f. region of 1000 Mc/s over the nearly 500,000 mile distance from the earth to the moon and back. The tests were conducted at Fort Huachuca in Arizona. The transmitting station for the tests was located at Fort Huachuca, and the receiver was at Encino (New Mexico). The frequency of 810 Mc/s was utilized in order to increase the effectiveness of the aerial systems and to take advantage of lower signal losses in the transmission path.—*Telecommunications. Reports*, quoted by the *I.T.U. Journal*.

PEIPL receives v.h.f. signals from U.S.A.

On January 27 and 28, 1959, the Dutch Government Experimental Station PEIPL received signals on 151 Mc/s from a station in New Jersey, U.S.A., via the Moon. The transmitter had an output power of 50 kW c.w. and the strength of the received signals was 0·2 μV.